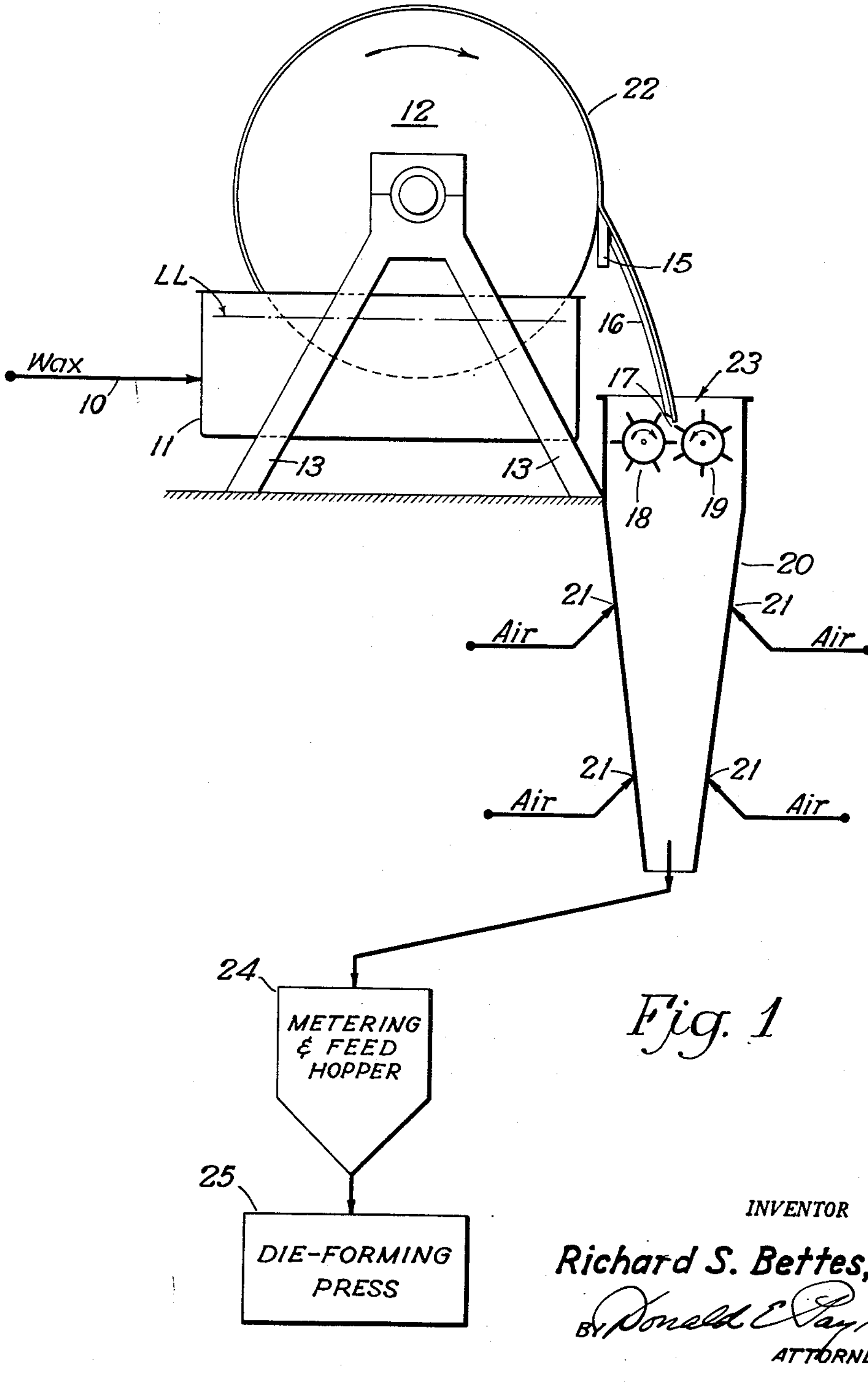

Fig. 1

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Dec. 14, 1954

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2,696,650

COMMINUTING APPARATUS

Original Filed June 9, 1950

2 Sheets-Sheet 2

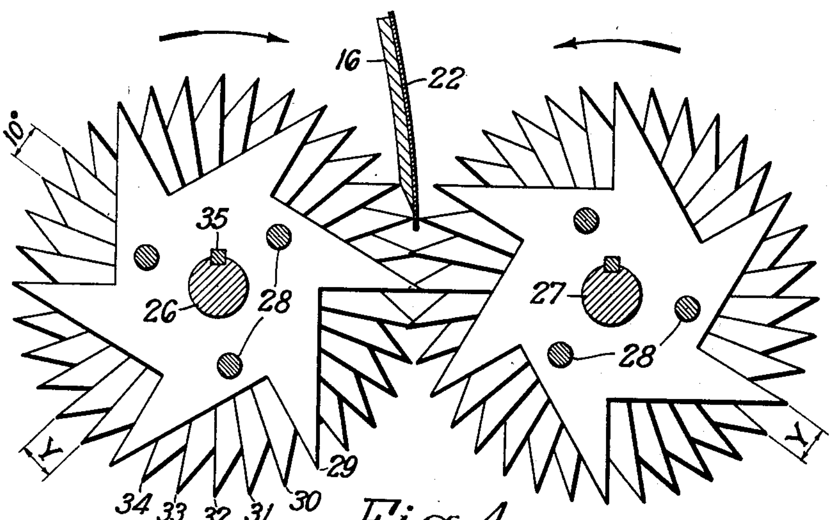

Fig. 4

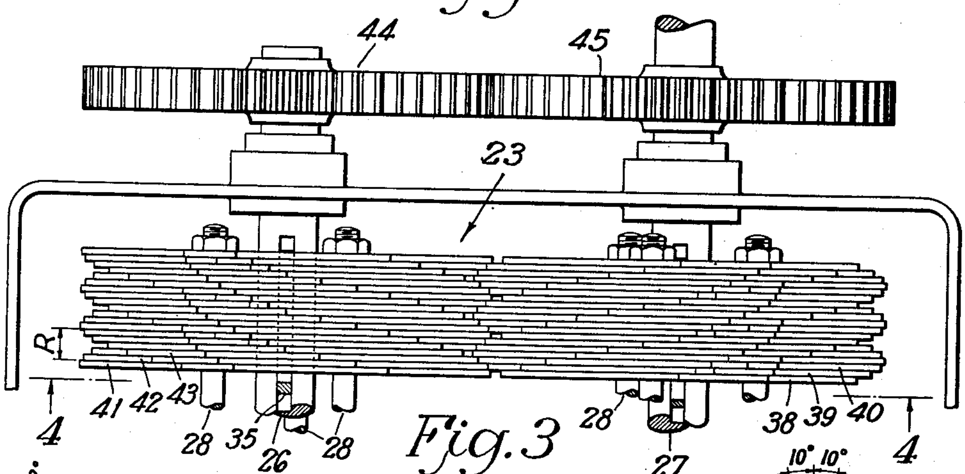

Fig. 3

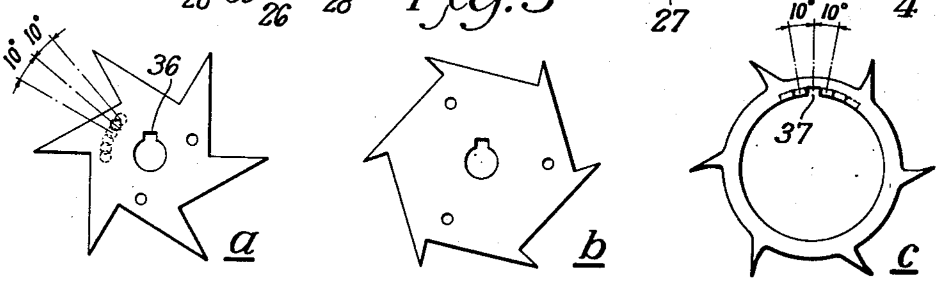

Fig. 2

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Patented Dec. 14, 1954

2,696,650

COMMINUTING APPARATUS

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Original application June 9, 1950, Serial No. 167,216. Divided and this application September 26, 1950, Serial No. 186,805

4 Claims. (Cl. 25—110)

This invention relates to an apparatus for producing discrete particles from substances in a plastic or semi-solid state. In particular, the invention relates to the comminution of films or sheets of normally brittle substances, such as paraffin wax and the like, which pass through a plastic or semi-solid state while being transformed from a liquid to a solid.

In the preparation of cakes or decorative objects by compressing discrete particles of wax it is essential that the wax be in a very finely divided state and that the particles be substantially uniform in size. Normally brittle materials, such as paraffin wax, have heretofore been transformed into particulate solids with great difficulty and by the best methods available it has not been possible, in a commercially feasible manner, to produce finely divided wax suitable for a die-compressing operation.

It is commercial practice to produce relatively large flakes of paraffin wax or like materials by scraping brittle wax from the surface of rotating drum chillers or flakers. Such drums are ordinarily operated at a sufficiently low temperature to yield a brittle film on the surface of the drum which is flaked at the doctor blade employed to strip the film from the drum. The relatively large non-uniform flakes so produced may be passed through counterrotating breakers or sizers in order to produce slightly smaller and somewhat more uniform wax flakes and for many purposes such flakes are entirely satisfactory but they are not suitable for die-compressing purposes. The brittleness of solid wax which prevents its removal from the drum without fragmentation has likewise prevented the satisfactory production of discrete particles by other prior art methods.

In order to eliminate the problems associated with such a brittle film a novel process for the production of uniformly particulate solids from a flexible film of wax or other material has been developed which is disclosed and claimed in copending application for Letters Patent Serial No. 167,216 filed June 9, 1950, of which this application is a division. According to the process described in that application a plastic or semi-solid film, produced on a rotating drum cooler by maintaining the drum's surface at a substantially higher temperature than that employed in the flaking operation described above, is cut into discrete particles as it is stripped from the drum in a continuous ribbon. The preferred comminuting means which is disclosed but not claimed in that application is the subject of this invention and shall be described with particular respect to the process set forth in the copending application. By means of the novel apparatus which is disclosed and claimed herein paraffin wax or like material may be reduced to finely divided particles in a continuous and commercially feasible manner with none of the disabilities of methods heretofore employed.

It is an object of this invention to produce uniformly particulate solids from normally brittle materials such as paraffin wax. A further object is to provide a means for uniformly comminuting films or sheets of such materials while in the plastic or semi-solid state. Another object is to provide a cutting device adapted to continuously comminute such films into finely divided solids by cutting from opposite sides of the film. These and additional object will be apparent from the specification and claims hereinafter set forth.

Throughout the specification and the claims which follow the terms "semi-solid" and "plastic," when referring to the wax film or to the particulate wax solids, shall be

understood as being synonomous and as descriptive of paraffin wax or equivalent material which is sufficiently pliable to ride over the scraper blade in a continuous ribbon or film. The temperature range within which a paraffin wax is in this condition is directly related to the melting point of the wax. Thus, a paraffin wax melting at 122° to 124° F. is in this condition at a temperature in the range of from about 30° F. to about 40° F. below its melting point and this range may be readily ascertained for any melting point wax. Within these ranges the normally brittle nature of wax is supplanted by the plastic or semi-solid and it is to the comminution of films of wax or equivalent material in such a condition that this invention is particularly directed.

In essence the invention comprises a means for obtaining uniformly particulate solids by a substantially simultaneous cutting action from each side of a film of plastic material. Since a film of wax or equivalent material in the plastic condition can not be scraped, abraded or crushed it is necessary that it be cut or torn. In a preferred embodiment of this invention cutting is obtained by means of two parallel counterrotating multi-tooth cutters which intermesh a distance at least equal to the thickness of the film to be comminuted. The film may vary in thickness over a relaitvely wide range but as a practical matter it should be of from about 0.01 to about 0.125 inch in thickness. Since the film is so thin, cutting is necessary only in a direction substantially perpendicular to the film. The opposing cutters are set relative to one another so that no contact between coacting teeth is possible and their shafts are geared together to maintain this relationship. The cutters operate at high speeds to comminute the film in a finely divided manner but may be operated at lower speeds if larger particles are desired.

In the accompanying drawings:

Fig. 1 is a diagrammatic representation of a complete process for producing solid objects from molten wax via particulate solids, with the novel comminuting device shown diagrammatically only for the purpose of showing the relative positions of equipment.

Figs. 2*a*, 2*b* and 2*c* represent some alternative cutter blade designs for the preferred embodiment of this invention, Fig. 2*a* being the blade design embodied in the cutters of Figs. 3 and 4.

Fig. 3 is a partial plan view of a preferred embodiment of the cutting device shown diagrammatically in Fig. 1.

Fig. 4 is a sectional view of the cutters shown in Fig. 3 taken along lines 4—4.

Referring to Fig. 1 a paraffin wax having a melting point of 122° to 124° F. is introduced at a temperature of from about 25° to 75° above its melting point via line **10** into wax tank **11**. It is recommended that the wax be at a temperature sufficiently above its melting point to minimize undesired caking of the wax. The five foot diameter drum **12** having a length of twelve feet is rotatably positioned on supports **13**. The drum is rotated at from about 2 to about 10 revolutions per minute (by means not shown) in such a manner as to permit the continuous immersion of a segment of the periphery of the drum in the molten wax. The cooling drum employed in the process is of standard construction and is well known to the art and while it is preferred to use this means of obtaining a substantially continuous film of plastic wax or any other method whereby such a film is produced may be satisfactorily employed. A typical example of the type drum which is suitable for the process is shown in U. S. 1,361,346. In general all of the mechanical details which are essential to the satisfactory operation of this drum are well known to the art, hence no detailed description of this apparatus is necessary. It is preferred to direct a continuous spray of coolant against the top of the inside of the drum which results in a continuous falling film of coolant along the drum walls. The coolant is continuously removed from the bottom of the drum by a suction pump.

As drum **12** is rotated through the molten wax a continuous film of wax **22** is formed on the outer surface of the drum which is at a temperature substantially below the solidification point of the wax. It is preferred that the film coming off of the drum and entering the cutters be within the range of from about 30° to about 40° F. below the melting point of the 122° to 124° F. wax. This temperature range embraces the so-called plastic range of the 122° to 124° F. wax and it is only within that range that the cutters operate efficiently; below about 82° F. the film coming off the drum tends to be brittle while above about 94° F. it is too soft. Whereas the plastic range varies according to the melting point of the wax employed so also does the temperature of the wax film entering the cutters vary with the speed of rotation of the cooling drum, the temperature of the coolant and the rate of introduction of the coolant. These phenomena will be hereinafter more fully described. As the drum rotates, the wax film **22** is continuously stripped off by scraper blade **15** which is in continuous contact with the outer surface of the rotating drum. The wax film **22** which is stripped from the drum by scraper blade **15** passes over the wax guide **16** cooperatively positioned below the scraper blade in such a manner as to guide the wax film to a point **17** at the intersection of the outer circumferences of the circles formed by the rotation of the teeth on cutters **18** and **19**. It is essential that wax guide **16** be at a temperature low enough to prevent sticking of the wax film as it is directed to the cutters. Additional cooling may be obtained by any suitable means such as a stream of cooled air on the underside of the guide or by employing a hollow guide and internally cooling by the same medium that cools the drum **12**. The wax film passes into the cutting device **23** and is comminuted by the rotation of cutters **18** and **19** toward the wax film.

For satisfactory comminution it is essential that the wax film approaching the cutters be within the plastic range yet not too warm. Generally, achieving a film temperature in this range will not be difficult, since with solidification of the wax as the drum turns the wax temperature will fall rapidly to about this temperature. However, should the drum speed be too low or the cooling rate too high the film may be cooled to below about 82° F., become brittle, and as a result break into non-uniform fragments at the scraper blade or in the cutters. On the other hand if these conditions are reversed the film becomes too soft, is not properly comminuted and tends to foul the cutters. Adjustment of both drum speed and cooling water flow rate are therefore necessary for control of film temperature as well as production capacity.

The particulate wax solids formed by the cutting of wax film **22** fall through a collecting chute **20** and into the metering and feed hopper **24**. Proper passage of the wax particles through the chute and into the metering and feed hopper demands that the particle temperature (at least on the surface of each particle) be at a lower temperature than that at which the wax strip enters the cutter. A temperature between about 70° and 80° F. is preferred. As these wax solids descend from the cutting device they are contacted with an inert cooling gas, preferably air, introduced at suitable points **21** in chute **20**. This cooling gas may be direcetd at the falling wax by any suitable method, the purpose of contacting this wax being to lower its temperature and thereby lessen its tackiness in order to substantially prevent the adherence of the more or less semi-solid particles with one another and to the sides of the equipment. It is advantageous under certain circumstances, rather than merely contacting with a cooling gas, to provide an air conditioned space in which the particles fall; this is particularly desirable when the air in the vicinity contains substantial amounts of impurities which destroy the quality of the wax. From the hopper **24** the wax particles are automatically fed in metered amounts to the continuous die-forming press **25**. While both the metering and feed hopper and die-forming press are commercially available devices requiring no detailed description, they will be referred to briefly hereinafter.

The blade shown in Fig. 2*a* corresponds to those embodied in the cutters shown in Figs. 3 and 4. These blades are formed from sheet metal by a suitable means such as stamping and should not have a thickness greater than about 0.065 inch. All of the blades embodied in cutters **18** and **19** are identical in physical dimensions except for possible slight variations in thickness. Each blade on the cutter differs however, from those juxtaposed thereto in the position of the three smaller holes which are bored about the center hole of the blade to permit its alignment on guide rods **28**. The manner in

which these holes are positioned will be hereinafter more fully described. For the purpose of this example the diameter of each blade is 8 inches.

In Fig. 4 the cutters are seen from an end view and while only six blades on each cutter are visible, reference to Fig. 3 indicates that there are a plurality of blades in alignment with each of the visible blades. Thus, there are 36 axial rows of teeth about each rotatable cutter, the teeth in each axial row being separated by the thickness of five blades. This distance between teeth in an axial row is designated as R in Fig. 3. Because of slight variations in sheet metal thickness it is possible in actual construction that the distance R will not remain constant for the entire length of the cutter, so that in a cutter of substantial length, e. g. 12 feet, the blades such as **38** and **41**, **39** and **42**, **40** and **43**, etc., respectively as shown in Fig. 3 tend not to be in the same vertical plane as in Fig. 3 and the likelihood of contact between cutters is increased. Taking into consideration such an ocurrence the cutters are designed so that the axial rows of teeth may intermesh; thus, if it were found that the cutters shown in Figs. 3 and 4 were striking one another it would be necessary only to disconnect gearing **44** and **45** which fix the relative movements of the two cutters, rotate either cutter 5° while holding the other cutter fixed and then to reconnect the gearing. It may be desirable to set the cutters in this manner originally to remove any possibility of contact.

The opposing cutters need only intermesh a distance equal to the thickness of the wax film passing between them and they must intermesh without striking. Based on these principles, the number and shape of teeth may be varied considerably as shown in the alternative blade designs in Figs. 2*a*, 2*b* and 2*c*. It is preferred in the process to have as many teeth on the cutters as possible in order to have the number of teeth striking the wax film per linear inch substantially maximum.

Referring to Fig. 4, the blades **29**, **30**, **31**, **32**, **33** and **34** comprise what is referred to herein as a pattern cycle and it may be seen from Fig. 3 that this pattern cycle is repeated many times on each cutter. The distance between the axial rows of teeth formed by the tips or apexes of the teeth in repeating pattern cycles, is an important factor in cutter design. The distance should be about ½ inch to an inch preferably about 0.70 inch regardless of the diameter of the cutters or the number of teeth per blade. It should not be substantially greater than about one inch because of the attending increase in particle size at any given angular velocity nor may it be substantially less than ½ inch because of the necessity for intermeshing of opposing rows of teeth without contact. This distance is indicated in Fig. 4 as Y. As may be seen from the following equation the distance Y is actually the distance along the arc between tips of teeth but for all practical purposes, when dealing with cutters of about 8 inch diameter and greater, this distance may be considered as the linear distance between tips of teeth, i. e. the chord of the arc.

Set forth below are mathematical formulae which will enable one skilled in the art to design a cutter suited to his needs.

$$(1)\quad \frac{\pi D}{N}=0.70 \text{ inch (approximate distance)}$$

or

$$N=4.488D$$

$$(2)\quad I=\frac{N}{n}=4 \text{ or a large integer}$$

wherein

D=cutter diameter
N=number of axial rows of teeth per cutter
n=number of teeth per blade
I=number of blades per pattern cycle

Since the number of rows of teeth per cutter must be numericaly divisible by a whole number in order to obtain the number of teeth per blade the distance between rows of teeth will of course vary slightly from 0.70 inch in order to give this desired result. The distance between teeth in an axial row is important in that ribbons of wax will result if these teeth are too close together. If fewer than four blades are positioned between the teeth in an axial row the comminution is not entirely satisfactory. Following is an example of a design calculation for the 8 inch diameter cutters shown in the drawings.

Example

$$\frac{\pi D}{N}=0.70 \text{ (approximate distance)}$$

$N=4.488$ (D)
$N=4.488$ (8)
$N=35.904$—or 36 (taking nearest whole number divisible by a suitable I, e. g. 6)

Checking back in the original formula and changing 0.70 to Y the actual distance between teeth is determined:

$$\frac{\pi(8)}{36}=Y$$

$Y=.6981$ inch (actual distance)

$$I=6=\frac{36}{n}$$

$n=6$ teeth per blade.

The 8 inch diameter cutter described herein has six teeth per pattern cycle and 36 axial rows of teeth on the cutter, thus the rows of teeth are separated by an angle of 10°. At 10° the actual distance between teeth as shown in the above example is 0.6981 inch. While I find that the use of the 0.70 inch as the distance between rows enables me to design the cutters for a substantially maximum number of teeth for any diameter cutter this distance can be varied slightly within the limits set forth. A distance above about 0.65 inch is preferred in order to eliminate any danger of contact between opposing cutters and at the same time maintain excellent particulation. It is feasible to cut 8 inch diameter blades having eight teeth which would then be positioned on the shaft so that the pattern cycle would have five teeth 9° apart and the entire cutter would have 40 rows of teeth instead of 36 which would be an increase of 11.1% in number of rows. Since the pattern cycle would then have five blades rather than six there would be 20% more teeth per row which gives an overall increase in number of teeth amounting to 33%. With that design, rather than 0.6981 inch, the distance between rows would be 0.6033 inch. It is ordinarily unnecessary to approach the absolute maximum number of teeth and minimum distance because the distance of about 0.70 inch between rows of teeth gives a very finely comminuted wax. In any event the slightly increased particle size encountered by not having the maximum number of teeth can be readily offset by an increase in the angular velocity of the cutter.

Guide rods **28** fix the position of the cutter blades relative to one another. The three guide holes on each successive blade in a pattern cycle are 10° removed from those on the adjoining blades. Thus the blades are positioned at six different relative locations about the center hole corresponding to the angle at which each blade in a pattern cycle is positioned on guide rods **28**. Fig. 2*a* indicates with respect to one hole how all three holes are bored in successive blades. The cutter blades may be permanently affixed to the rotatable shafts **26** and **27** by various means such as a key running the length of each shaft positionable in slots in the cutter blades as shown in Fig. 2*a* or by passing the guide rods through flanges pinned to the shafts at each end of the plurality of cutter blades. The blade shown in Fig. 2*c* does not have the three holes for the guide rods as do those in Figs. 2*a* and 2*b*. The slot **37** is cut in each blade of a pattern cycle at a position 10° removed from its adjoining blades and serves the dual purpose of fixing the relative positions of the blades and permanently fixing the blades to the shaft. The geometrical pattern of the rows of teeth need not conform to the straight axial pattern shown in the drawings but may comprise a helical design or the like as long as the requirements for intermeshing, as set forth above, are fulfilled.

Whereas the drawings and description hereinbefore set forth relate to a preferred embodiment wherein the blades on opposing shafts form axial rows of teeth which intermesh with the rows of teeth on opposing cutters, it is also possible to employ cutter blades on the opposing shafts which are in alternating vertical planes and which may have substantially more teeth. When the teeth of opposing cutters do not intermesh but coact in an alternating manner so that each blade on either cutter will extend approximately the thickness of the wax film between two blades on the opposing cutter the need for fixed connection **44** and **45** between cutters is eliminated because contact between the teeth of opposing cutters is impossible; the geared connection may be employed, however, rather than having a driving means on each shaft. In addition to the modification in relative positions of the opposing cutter blades the shape of the teeth on the blades may also be varied as is shown in Figs. 2*b* and 2*c*.

It is ordinarily satisfactory if each cutter blade positioned on the rotatable shafts is positioned flush against its adjacent blades but it is desirable under certain conditions to position spacer elements between each adjacent blade, e. g. where extremely thin cutter blades are employed or when employing the alternating blade arrangement described above wherein the teeth of opposing cutters do not intermesh and it is necessary to have each blade on both cutters extend between two blades on the opposing cutter.

The basic principle on which the cutters operate is that the teeth of opposing cutters should cut into the wax ribbon approximately perpendicularly from each side, thus other embodiments whereby this is accomplished which do not depart from the spirit of this invention will be apparent to one skilled in the art. It is felt that for ease of fabrication and simplicity of design the embodiment is preferred which is herein set forth in detail.

Proper positioning of the film guide is extremely important. Satisfactory comminution is dependent to a great extent upon both cutters sharing equally in the cutting. Thus, they will be cutting substantially simultaneously from both sides of the film and this action will serve to hold the leading edge of the film at the point of intersection of the teeth. Should the guide or the wax itself be displaced in the direction of one of the cutters, that cutter will exert a beating action on the wax film and a preponderance of large ribbons will result. Fig. 4 clearly shows the relation of the wax guide **16**, wax film **22** and cutters **18** and **19** to one another.

The wax particles are die formed in automatic presses of the plastics preform type. In general, the tooling on these presses consists of a stationary die cavity of dimensions equal to those of the flat surface of the piece to be formed, a movable upper punch which applies pressure to the material in the die, and a movable lower punch which forms the bottom of the die cavity during pressing. Feeding is accomplished by means of a reciprocating feed hopper timed with the other movements of the press so that it can travel in over the empty die cavity, deposit a volumetrically controlled amount of granulated material and withdraw to allow for pressing. In addition to automatic filling, the feeder serves to eject the finished piece which is carried to the top of the die cavity by the motion of the lower punch. The pressing cycle is completely automatic, and the necessary adjustments for controlling size and weight can readily be made. Both hydraulic and mechanical preform presses are available commercially.

Not only is it essential that the particulate wax produced be substantially uniform in size but it is also necessary that the particle size be held within certain limits. This limitation is established by two principle factors namely length of the stroke of the press and the appearance and physical characteristics of the finish cake. Since each press is limited as to length of stroke, the total depth of unpressed particulate solid necessary to form a cake of the desired thickness is limited thereby. The finer the wax is cut, the lower the depth of uncompressed solids. In addition the more finely divided wax yields more uniform structure and surface finish to the pressed cake. In order to classify the particulate wax according to size it has been found that it is best described by reference to its "Bulk Ratio." The "Bulk Ratio" of particulate wax is that figure which represents the ratio of a volume of unpressed wax to the volume of a solid cake produced from the unpressed wax. Since the volume of particulate wax will vary with settling, two volume measurements are ordinarily made on the unpressed wax: one immediately after pouring into a measuring vessel and another after forced settling caused by light tapping on the vessel has ceased. In table I below, the "maximum" figures relate to the volume measurement taken immediately and the "minimum" is that after light tapping.

TABLE I

Bulk ratios of samples of granulated paraffin wax

Cutter Speed, R. P. M.	Drum Speed, R. P. M.	Bulk Ratio	
		Max.	Min.
2,080	4½	4.0	3.0
2,760	4½	3.3	2.5
3,100	4½	3.0	2.4
4,450	4½	2.9	2.6

It can be seen from above table that the "Bulk Ratio" varies substantially with cutter speed. It has also been found to vary with the speed of the wax film, i. e. increased wax film speed is accompanied by an increase in bulk ratio. However, this variation is considered slight and can readily be accommodated by increasing the speed of the cutters.

The degree of particulation necessary for process operation is primarily limited by the design of the press. Many presses suitable for this operation require that the bulk ratio of the material being handled be less than 3½. A maximum bulk ratio slightly higher than 3½ might be tolerated since the slight vibration of the feed mechanism tends to pack the material.

In order to regulate the rate at which the particulate wax solids fall through the chute and enter the metering and feed hopper it may be desirable to introduce the air in the lower regions of the chute at such a velocity that the particulate wax is fluidized and has a net downward movement at a rate considerably less than free falling wax or wax propelled rapidly from the teeth of the cutters. In this manner piling of the wax is substantially eliminated and the proper amount of wax for the die press can be continuously fed to the feed hopper.

It shall be understood that various changes and modifications may be made in the novel apparatus without departing from the spirit thereof and while the process and apparatus have been described specifically with respect to paraffin wax they are adaptable for other waxes, both natural and synthetic as well as to materials such as soap, detergents, polyethylene and other organic or inorganic materials which do not decompose upon melting, do not sublime and which will form a substantially continuous film of readily comminutable solid.

I claim:

1. A comminuting device for producing substantially uniform particles from a film of plastic material, which device comprises parallel rotatable shafts adapted to be rotated at high speeds; means for counter-rotating said shafts at such speeds; a multiplicity of pointed cutting teeth having a thickness no greater than about 0.065 inch disposed about each shaft, each tooth being angularly offset with respect to at least the three teeth on each side thereof so as to form a plurality of equidistant axial rows of teeth about said shafts, the peripheral distance between said rows of teeth being from about ½ inch to about 1 inch and the linear distance along said shaft occupied by any group of adjacent teeth being not substantially greater than the combined thicknesses of said teeth; the said parallel shafts being so disposed that upon counter-rotation thereof the tips of the teeth in each axial row may extend into the space between the tips of two rows on opposing shafts a distance at least equal to but not substantially

greater than the thickness of the film to be comminuted and without contact between opposing teeth.

2. A comminuting device for producing substantially uniform particles from a film of plastic wax which device comprises two rotatable parallel shafts adapted to be rotated at high speeds; means for counter-rotating said shafts at such speeds; a multiplicity of substantially identical cutter blades having a thickness no greater than about 0.065 inch juxtaposed on each shaft, each of said cutter blades embodying a plurality of evenly spaced, pointed teeth and being angularly displaced on said shafts with respect to adjacent blades to form a plurality of substantially equidistant axial rows of teeth about each shaft, the number of said axial rows being at least four times the number of teeth on an individual blade and the peripheral distance between said axial rows being from about ½ inch to about 1 inch; said parallel shafts being so disposed that upon counter-rotation thereof the tips of the teeth in each axial row may extend into the space between the tips of two axial rows on the opposing shaft, a distance at least equal to but not substantially greater than the thickness of the film to be comminuted and without any contact between opposing teeth.

3. The comminuting device of claim 2 wherein there are at least about 6 teeth on said cutter blades.

4. A comminuting device for producing substantially uniform particles from a film of plastic material which device comprises parallel rotatable shafts adapted to be rotated at high speeds; means for counter-rotating said shafts at such speeds; a multiplicity of cutting teeth disposed about said shafts in a plurality of axial rows and circumferential rows, each tooth having a thickness no greater than about 0.065 inch, the peripheral distance between axial rows being from about ½ inch to about 1 inch, the teeth in each circumferential row being angularly offset with respect to the teeth in the adjacent circumferential rows so that the number of axial rows about each shaft is at least four times the number of teeth in a circumferential row, and the sides of the teeth in each circumferential row being in substantially the same plane as the opposing sides of the teeth in the adjacent circumferential rows; the said parallel shafts being so disposed that upon counter-rotation thereof the tips of the teeth in each axial row may extend into the space between the tips of two rows on opposing shafts a distance at least equal to but not substantially greater than the thickness of the film to be comminuted and without contact between opposing teeth.

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